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**OBSERVATIONAL AND MODELING STUDIES OF HEAT, MOISTURE,
PRECIPITATION AND GLOBAL-SCALE CIRCULATION PATTERNS**

NAG8-836

Final Technical Report

July 20, 1990 - January 19, 1994

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(NASA-CR-195148) OBSERVATIONAL AND
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1. INTRODUCTORY REMARKS

This research grant was a revised version of an original proposal. The period of the grant was for three years with a six-month no-cost extension; thus, it was from 20 July 1990 to 19 January 1994. The objectives of the grant were to: (1) identify periods and locations of active convection centers, primarily over the Southern Hemisphere tropical Indian and Pacific Oceans; (2) determine reasons for any periodic behavior found in the first objective; (3) identify cases where subtropical jets over the South Pacific persisted for several days and examine the influences of tropical versus extratropical mechanisms in maintaining them; (4) obtain estimates of precipitation by Q_1 and Q_2 budgets, including the importance of terms in each of the respective budgets, and compare these estimates to those obtained by other methods; and (5) diagnose the distributions of moisture and precipitable water over the North Atlantic Ocean using routine analyses and satellite microwave data.

To accomplish these objectives, we used grant funds to purchase several data sets, including the Global Precipitation Climate Project (GPCP) observations of station precipitation, ECMWF WCRP/TOGA archive II analyses for January 1985 - December 1990, ECMWF WMO analyses for January 1980 - December 1987, and OLR data for July 1974 - December 1991. We already had some SSM/I data and GLA analyses from a previous grant. In addition, to improve our computing power, we also used grant funds to purchase an IBM PS/2 with accessories, a NEC laser jet printer, and a microcomputer system for word processing.

This report is organized as follows. Our research team is listed below. Section 2 contains a summary of our significant accomplishments; however, a detailed discussion of research results is not included since this information can be found in the accompanying reprints and preprints. Section 3 offers some concluding remarks, and a complete bibliographic summary is given in Section 4. In addition, as noted above, published under this grant are included with the report.

Research Team

Dr. Dayton G. Vincent
Dr. Franklin "Pete" Robertson
Dr. James W. Hurrell
Prof. Peter Speth
Dr. Mark Bourassa
Dr. Perry Ramsey
Dr. Thomas Sperling
Mr. L. David Sliwinski
Mr. Ken-Chung Ko
Mr. Jon Schrage
Mr. Robb Velasco
Mr. Mathew Eastin
Mr. Daniel Guertin
Ms. Helen Henry

Principal Investigator
Scientific liaison at MSFC
Scientific collaborator, NCAR
Scientific collaborator, Cologne, Germany
former graduate student, Purdue
former graduate student, Purdue
former graduate student, Cologne
former graduate student, Purdue
Ph.D. student, Purdue
M.S. student, Purdue
former undergraduate student, Purdue
undergraduate student, Purdue
undergraduate student, Purdue
secretary

2. SIGNIFICANT ACCOMPLISHMENTS

a. Awards/recognition

Each of the following students won awards, based on national competition, which are related to their involvement and/or contributions to this research grant.

- i. Mr. Robb Velasco was the 2nd place winner of the AMS Macelwane Award for his undergraduate research paper, "Diagnosis of Moisture Parameters in the Tropics Using Two Estimates of Precipitation Rates From 1 June 1984 - 31 May 1987", presented at the Annual Meeting in Atlanta, GA, January 1992.
- ii. Mr. Robb Velasco won an AMS Global Change Studies travel scholarship to attend the Annual Meeting in Atlanta, GA, January 1992.
- iii. Mr. Jon Schrage won an AMS Industry Fellowship which supported his first year of graduate study (1992-93) on our project.
- iv. Messrs. Jon Schrage and Dave Sliwinski won AMS Global Change Studies travel scholarships to attend the Annual Meeting in Anaheim, CA, January 1993.
- v. Mr. Jon Schrage won an NSF graduate fellowship which supports three years of graduate study on our project, beginning last fall semester.

In November 1992, Dr. Vincent was invited to present a seminar at the Institute for Geophysics and Meteorology, Cologne, Germany. In addition, in the spring of 1993, Dr. Vincent was invited to give a seminar at the Bureau of Meteorological Research Centre, Melbourne, Australia. He was also asked to chair a session at each of the following conferences which he attended because they related to research conducted under this grant:

- i. IAMAP meeting of the IUGG, Vienna, Austria, August 1991.
- ii. Fourth Symposium on Global Change Studies, Anaheim, CA, January 1993.
- iii. Fourth International Conference on Southern Hemisphere Meteorology and Oceanography, Hobart, Australia, March 1993.
- iv. Twentieth Conference on Hurricanes and Tropical Meteorology, San Antonio, TX, May 1993.

b. International activities

International activities have played a very important role in our research progress. Our collaborative research with the Institute for Geophysics and Meteorology at the University of Cologne, which began in the late 80's, has accounted for a majority of our international involvement. Professor Peter Speth from the Institute visited our research group for a few days on two occasions, once in the fall of 1990 and again in April 1992. Also in the fall of 1990, Dr. Vincent was invited to attend the week-long annual seminar series at ECMWF where the topic was, "Circulation Features of the Tropics and Interactions with Extratropical Latitudes". While there, he discussed research with Mr. Thomas Sperling, a graduate student from Cologne, who was also an attendee. At the time, Dr. Vincent was serving as a member of Mr. Sperling's Ph.D. advisory committee.

In September 1990, Mr. Perry Ramsey attended the Fifth Conference on Satellite Meteorology and Oceanography in London, England, and presented a poster on his Ph.D. research. In August 1991, Dr. Vincent presented papers at two sessions of the IAMAP meetings of the IUGG in Vienna, Austria. He also chaired a session. While there, he met with two graduate students from Cologne, Messrs. Andreas Fink and Thomas Sperling. They discussed their research with Dr. Vincent, since he was serving on both of their advisory committees. In January 1992, Dr. Mark Sinclair of New Zealand, visited our research group and presented a seminar. He has investigated cyclones in the vicinity of the SPCZ, a topic of long standing importance to our research interests.

In August 1992, Mr. Ramsey presented a poster session at the Eleventh International Conference on Clouds and Precipitation in Montreal, Canada. In September, Professor Eberhard Ruprecht from the Institute for Marine Sciences, Kiel, Germany, visited our research group and gave a seminar. His research expertise is in the area of microwave estimates of water vapor and precipitation. At the end of the year, Dr. Vincent spent six weeks at the Institute for Geophysics and Meteorology in Cologne. He taught a short course in "Tropical Meteorology", and conducted research with Professor Speth and Messrs. Fink and Sperling.

In March-April 1993, Dr. Vincent traveled to Australia where he presented an invited seminar at the Bureau of Meteorology Research Centre in Melbourne and attended the Fourth International Conference on Southern Hemisphere Meteorology and Oceanography in Hobart, Tasmania. At the conference, he presented a review paper on the SPCZ and chaired a session. Also in the spring of 1993, Drs. Vincent and Speth completed the establishment of a Faculty Exchange Program between their respective organizations. Dr. Vincent will be the first participant of this program in April 1994 when he will present some seminars on TOGA-COARE and conduct research with Professor Speth's group. To date, our collaborative efforts have resulted in one refereed publication (Vincent *et al.*, 1991), one preprint paper and accompanying conference presentation (Vincent *et al.*, 1991), an M.S. thesis by Andreas Fink in 1992, and a Ph.D. thesis by Thomas Sperling in 1993. In addition, we hope to prepare another manuscript while Dr. Vincent is in Cologne in April 1994. Lastly, Dr. Vincent is currently serving as one of the advisors for Mr. Fink's Ph.D. research.

c. Research visitors

- i. Professor Peter Speth (1990, 1992) from the University of Cologne, Germany.
- ii. Dr. Bill Lau (1991) from the GSFC/NASA.
- iii. Dr. Mark Sinclair (1992) from the New Zealand Weather Service.
- iv. Professor Eberhard Rapprecht (1992) from the University of Kiel, Germany.
- v. Dr. James Hurrell (1993) from NCAR.

3. CONCLUDING REMARKS

In the past 1-2 years, NASA's budget for basic and applied research has been severely cut and our group was informed last year that our funded research would most likely end with this grant. Fortunately, we received a one year grant, beginning September 1993, to help us complete the research associated with the Ph.D. work of one of the students (Perry Ramsey), funded under this grant. Dr. Ramsey recently completed his degree and presently we are preparing two manuscripts based on this thesis research. This work, as well as other research-related activities in 1994, will be included in the final report of the one-year NASA grant, under which we are currently funded.

4. DOCUMENTATION OF BIBLIOGRAPHIC REFERENCES

a. Refereed publications

Hurrell, J.W. and D.G. Vincent, 1992: A GCM case study on the maintenance of short-term subtropical wind maxima in the summer hemisphere during SOP-1, FGGE. Quart. J. Roy. Meteor. Soc., **118**, 51-70. (copy enclosed).

Ko, K.-C., and D.G. Vincent, 1994: A composite study of the maintenance of subtropical wind maxima over the South Pacific during November 1984 - April 1985. (submitted to J. Climate). (Abstract provided).

Vincent, D.G., 1994: The South Pacific convergence zone (SPCZ): A review. Mon. Wea. Rev., **122** (to appear in the October issue). (Abstract provided).

Vincent, D.G., K.H. North, R.A. Velasco and P.G. Ramsey, 1991: Precipitation rates in the tropics based on the Q₁-budget method: 1 June 1984 - 31 May 1987. J. Climate, **4**, 1070-1086. (copy enclosed).

Vincent, D.G., T. Sperling, A. Fink, S. Zube and P. Speth, 1991: Intraseasonal oscillation of the convective activity in the tropical Southern Hemisphere: May 1984 - April 1986. J. Climate, 4, 40-53. (copy enclosed).

b. Conference preprints (copies enclosed)

Bourassa, M.A., 1993: An air/sea flux model including the effects of capillary waves. Preprint, 20th Conference on Hurricanes and Tropical Meteorology, 10-14 May 1993, San Antonio, TX, Amer. Meteor. Soc., Boston, MA, 386-389.

Sliwinski, L.D. and D.G. Vincent, 1993: A climatological study of the TOGA-COARE region. Preprint, 20th Conference on Hurricanes and Tropical Meteorology, 10-14 May 1993, San Antonio, TX, Amer. Meteor. Soc., Boston, MA, 543-546.

Vincent, D.G., 1992: A case study of analyzed versus satellite-derived water vapor distributions over the Atlantic Ocean. Preprint, Sixth Conference on Satellite Meteorology and Oceanography, 5-10 January 1992, Atlanta, GA, Amer. Meteor. Soc., Boston, MA, 329-332.

Vincent, D.G., 1993: A review of the South Pacific convergence zone (SPCZ). Preprint, Fourth International Conference on Southern Hemisphere Meteorology and Oceanography, 29 March - 2 April 1993, Hobart, Tasmania, Australia, Amer. Meteor. Soc., Boston, MA, 6-10.

Vincent, D.G., J.W. Hurrell, P. Speth, T. Sperling, A. Fink and S. Zube, 1991: Relationship between intraseasonal oscillation and subtropical wind maxima over the South Pacific Ocean. Preprint, Fifth Conference on Climate Variations, 14-18 October 1991, Denver, CO, Amer. Meteor. Soc., Boston, MA, 240-243.

Vincent, D.G., J.M. Schrage and L.D. Sliwinski, 1993: A case study of the intraseasonal oscillation traversing the TOGA-COARE LSD. Preprint, 10th Conference on Hurricanes and Tropical Meteorology, 10-14 May 1993, San Antonio, TX, Amer. Meteor. Soc., Boston, MA, 559-562.

Vincent, D.G. and L.D. Sliwinski, 1993: Some climatological variables for TOGA-COARE domains: 1985-1990. Preprint, Fourth Symposium on Global Change Studies, 17-22 January 1993, Anaheim, CA, Amer. Meteor. Soc., Boston, MA, 413-417.

c. Invited talks

Dayton G. Vincent, November 1992, at the Institute for Geophysics and Meteorology, University of Cologne, Germany.

Dayton G. Vincent, March 1993, at the Bureau of Meteorology Research Centre, Melbourne, Australia.

d. Conference presentations

In addition to those talks already listed in Section 4b, the presentations listed below were given at national and international conferences.

- i. Mark Bourassa, January 1993, Eighth Conference on Applied Climatology, Anaheim, CA.
- ii. Perry Ramsey, September 1990, 5th Conference on Satellite Meteorology and Oceanography, London, England.
- iii. Perry Ramsey, August 1992, Eleventh International Conference on Clouds and Precipitation, Montreal, Canada.
- iv. Dayton Vincent, August 1991, IAMAP Symposium on Large-Scale Flow and Variability, IUGG, Vienna, Austria.
- v. Dayton Vincent, August 1991, IAMAP Workshop on Precipitation Measurements, IUGG, Vienna, Austria.
- vi. Dayton Vincent, May 1991, Annual Research Review, MSFC/NASA, Huntsville, AL.
- vii. Dayton Vincent, July 1992, Annual Research Review, MSFC/NASA, Huntsville, AL.

e. Theses

Bourassa, M.A., 1993: An air-sea interaction model for stress, sensible heat, latent heat, and sea state, applicable to the full range of wind speeds. Ph.D. thesis, Department of Earth and Atmospheric Sciences, Purdue University, West Lafayette, IN 47907, 92 pp.

Hurrell, J.W., 1990: Maintenance of short-term subtropical wind maxima in the Southern Hemisphere: Observational and modeling study. Ph.D. thesis. Department of Earth and Atmospheric Sciences, Purdue University, West Lafayette, IN 47907, 160 pp.

- Ko, K.-C., 1990: Baroclinic (shear) and barotropic (mean) kinetic energy study of Southern Hemisphere subtropical wind maxima. M.S. thesis. Department of Earth and Atmospheric Sciences, Purdue University, West Lafayette, IN 47907, 54 pp.
- Ramsey, P.G., 1993: Radiative cooling profiles calculated from ECMWF analyses and ISSCP C1 data, and their application to determination of distributions of apparent convective heating in the equatorial Pacific. Ph.D. thesis, Department of Earth and Atmospheric Sciences, Purdue University, West Lafayette, IN 47907, 163 pp.
- Sliwinski, L.D., 1993: A climatological study for TOGA-COARE domains: 1985-1990. M.S. thesis, Department of Earth and Atmospheric Sciences, Purdue University, West Lafayette, IN 47907, 151 pp.
- Velasco, R.A., 1991: Diagnosis of moisture parameters in the tropics using two estimates of precipitation rates from 1 June 1984 - 31 May 1987. B.S. Honors thesis, Department of Earth and Atmospheric Sciences, Purdue University, West Lafayette, IN 47907, 77 pp.